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Optimization of Banana Fruit Cold Storage Monitoringand Control System using IoT

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***Abstract*—** The Internet of things(IoT) aims at connecting different objects, things using the internet. The rapid development of the Internet of Things(IoT) motivates us to apply for the food preservation domain such as maintaining the quality of banana fruit. In this project, a controlling and a monitoring unit has been proposed to analyze the ambient conditions under which the banana fruit is being stored and control the environment accordingly to help in ripening. The proposed solution senses the temperature and humidity parameters of the surrounding environment as these parameters affect nutritional values of banana fruit.

Keywords:- Internet of Things (IoT), Embedded and Automation, Remotely Monitoring and Controlling (RMC),banana fruit safety, Sensing Environments.

INTRODUCTION

The Internet of Things (IoT) is an emerging technology and is now completely transforming the ways in which industries operate. Forbes calls “the Internet of Things a giant network of connected things,with relationships between people-people, people-things and things-things”. The Internetof Things is defined as “the infrastructure of the information society”. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems.Quality of fruits and vegetables has a huge impact on the surroundings during storage. We can only maintain the quality of fruits and vegetables after harvesting; therefore it is important to store itin a proper ecosystem. Quality is a complex perception of

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many attributes that are simultaneously evaluated by the consumer either objectively or subjectively. Fruits and vegetables are highly perishable due to variation in temperature while they are stored. The effective observation of temperature, humidity, ventilation and other ecological conditions inside a distribution center has turned out to be one of the most challenging aspects of storage and many countries are trying to develop new technologies to overcomethis challenge. There is plenty of work to be done in this fieldand it has a lot of potential.

A Psychological study on bananas tells us that storage life will decrease even if temperature slightly increases over the range of 15℃ to 30℃. This is due to the relationship betweenthe ripening period and temperature that causes food respiration. The enzymatic reactions and their rates increase rapidly with an increase in temperature causing ripe fruit to spoil and peels to get dark. Ethylene (C2H4) gas is a natural plant hormone that helps in the ripening of fruits. So the main objective of our project was to design an automated system from which the user can manage the environment of the storage room's temperature, humidity and gas values from anywhere which will help the fruit to ripe and protect it from getting detroit.To maintain the temperature, humidity and ethylene gas of the storage room we are using AC and exhaust fan and they are being monitored by two sensors DHT11(Digital Temperature and Humidity) sensor and MQ3 sensor respectively.We are also using two wifi modules, NODE MCU (micro controller unit) ESP8266, in which one module acts as a monitoring unit and the other acts as a controlling unit. The monitoring unit interacts with sensors and the controlling unit is linked with an AC,gas valves and exhaust fan.

To reduce human efforts our whole system can be controlled and managed through website which has Mysql as a databasemanager and HTML (Hypertext Markup Language) is used for designing the website, we are also using php as a server-side scripting language, this means the executed php script builts output on the server and the output result is sent as HTML to the client browser for rendering. On our website we have different tabs for each storage room represented as a chamber as we have four chambers so each tab for each chamber. Under each chamber tab there are three more different tabs for control, timer and maintenance in which control tab is used for the on/off of the Air conditioner (AC) system, the gas valve and the exhaust fan of each chamber. Timer tab is used for setting the timer for the three systems

Our prototype will be helpful in many food storage industries.

I. LITERATURE REVIEW

This work deals with monitoring temperature of the freezer over a predetermined time period,storing the readings and then computing the results in order to inform the necessary maintenance procedures.The purpose of this project was to take preventive measures for maintenance of freezer before itaffects the quality of food as temperature is the major factor affecting the quality of food[1].

This work deals with transforming an old refrigerator into a smart economical machine employing sensors by installing a smart refrigeration module. It is capable of informing people about the food products current state using an android app on the phone. The purpose of this project was to make a smart refrigeration module which is more user friendly and economically sound[2].

This work ideates that Internet of Things (IoT) enables information collecting, real-time business development control, and the visualization of operational supply chain operations.IoT supports the food business by preserving safety standards, reducing food waste, managing unforeseen changes, and tracking and monitoring the food quality.Thus,IoT systems used in the food sector are therefore heavily researched in the body of existing literature[3].

Monitoring of cold storages is a tedious task and it is made easy using Internet of things technology. This paper proposes Wireless Sensor Network (WSN) based continuous monitoring of temperature and humidity of the cold storage warehouses using IoT concepts in order to ensure that the stored food products are not decayed due to increase in temperature and humidity[4].

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Cold Chain monitoring is a logistics or supply chain monitoring solution that helps to track the perishable products, eatables and food items with assured freshness and palatability[5].
Temperature sensor is a device that detects or measures hotness and coolness which is generated by the system and gives the signal. In a cooling system if the temperature rises
+1% then the temperature sensor gives the signal or notification to the manufacturer so that products do not decaydue to temperature rise[6].

"Interactive smart refrigerator" in which the refrigerators alert the user the lack of food products on the basis of the weight if the weight drops below the threshold,it alerts the user to order their groceries online [7]
"The paradox of warmth": Ambient warm temperature decreases preference for savory foods. This paper proposes their work deals with maintaining the warm temperature. The findings showed that warm ambient temperaturesreduced preferences for savory dishes while having no effect on preference for other items. The perceived food temperature, not the tastiness or healthfulness, was the basis for the lower preference for savory meals in warm ambient temperature. Understanding of the sensory impacts on consumer behavior can be advanced by including food temperature into thermoregulation theory.[8]
"The Design of the internet of Things Solution for FoodSupply Chain" : this paper proposes the idea that The internetof things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals orpeople that are provided with unique identifiers (UIDs) andthe ability to transfer data over a network without requiringhuman-to-human or human-to-computer interaction.[9] "Smart Temperature Monitoring System Using ESP32 andDS18B20": this paper deals with reducing human efforts in the field of storing fruits and vegetables. They continuouslytake values of the temperature over a time period, store the reading on the cloud and then compute the results to inform preventive measures for maintenance. They are using ESP32 and DS18B20 in their project. If there is an issue it sends ashort message service to phone number which is set on the phone.[10]

II. PROPOSED SYSTEM

A. Overview

This project develops a new approach towards IoT based systems which can track various sensor data and control the system accordingly to maintain the temperature as well as thegas levels in the storage room. The system uses a monitoring unit and a controlling unit in which controlling unit looks after the relays controlling industrial AC,Gas Valve and the Exhaust Fan and monitoring unit looks after the LCD(Liquid-crystal display) Display and taking data from the sensors. Currently we are using 2 microcontrollers ESP 8266 as our monitoring unit and controlling unit.Our first microcontroller will act as controlling unit and it will make arequest to the second microcontroller accordingly. Monitoring unit will provide the sensor data to the controlling unit which will then be sent to the cloud server.Now,according to the database on the backend of our server,our controlling unit will take action accordingly. Both Controlling and Monitoring unit will perform action as they are designated to and thus provide us with a fully automated system. On the cloud server,we will be able to see the Gas,Humidity and Temperature Levels as well as have buttons to control them through our server using IoT. The Gas used in this system will be Ethylene (C_2H_4) Gas which is generally used in ripening of fruits. The Gas Valve and the ACs will get on for 150 sec in every 6 hours i.e 4 times a day which is according to the data we received from the industry which is sufficient to ripen the banana fruit in a given time period in a storage room.Also,to maintain the temperature forevery 6 hours,we will have our exhaust fan on, so that the humidity and the temperature levels are maintained till the time AC gets on again i.e for every 6 hours.The temperature to be maintained will be around 16-22 degree Celsius.The communication between Controlling unit and our Cloud server will take place by using either HTTP (Hypertext transfer protocol) or MQTT (Message Queuing Telemetry Transport) Protocol and the

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communication between our Controlling and Monitoring unit will take place through ESP (Encapsulating Security Payload) - now protocol.

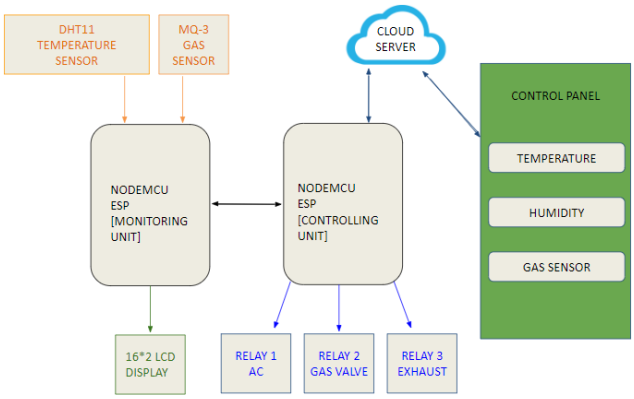

Fig 1. Block Diagram

B. System Components

Hardware Components

1. ESP 8266 Microcontroller
2. 16*2 LCD Display
3. 12V Industrial Relays
4. Sensors

i. DHT11 Temperature Sensor

ii. MQ3 Gas Sensor

1. ESP 8266 Microcontroller

Fig 2. NODEMCU ESP Module

The ESP8266 WiFi Module is a self contained SOC (system-on-a-chip) with integrated TCP (Transmission Control Protocol) /IP (Internet Protocol) stack that can give any microcontroller access to your WiFi (Wireless fidelity) Network. It is capable of either hosting an application or offloading all WiFi networking functions from another processor.

2. 16*2 LCD Display

Fig 3. 16*2 LCD Module

The 16*2 LCD (Liquid-Crystal) Display is a very basic module commonly used in DIYs and Circuits. 16*2

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meansthat this LCD can display 16 characters per line in 2 such lines.

3. 12V Industrial Relays

Fig 4. 12V Relay Module

In Industrial Applications,these relays are commonly used in control panels for various tasks such as monitoring power or controlling a motor. It is an electrically operated switch that recognizes an electrical input above a certain value,and carries out the control of opening or closing another circuit.

Sensors

i. DHT11 Temperature Sensor

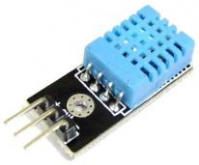

Fig 5. DHT11 Sensor Module

DHT11 (Digital Temperature and Humidity) is a 4 pin sensorwhich can measure temperatures ranging from 0- 50°C & relative humidity ranging from 20-95%.

ii. MQ3 Gas Sensor

Fig 6. MQ3 Sensor Module

The MQ3 Gas sensor Module is useful for gas leakage detection.It is suitable for detecting Alcohol as well as many gasses. Due to its high sensitivity and fast response time,measurements can be taken as soon as possible.

Software Components

1. Arduino IDE (Integrated Development Environment)
2. Adafruit
3. My SQL Database

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1. Arduino IDE

Fig 7. Arduino IDE Logo

The Arduino Integrated Development Environment[IDE] contains a text editor for writing code , a message area, a text console and a toolbar. It connects to the hardware such as
Arduino Board or ESP 8266 to upload programs and communicate with them.

2. Adafruit

Fig 8. Adafruit IO Logo

Adafruit IO is a platform designed to display,respond and interact with your project's data.

3. My SQL Database

Fig 9. MySQL Logo

MySQL is a database management system.

All the hardware components will be connected to our microcontroller through wires on the input ports of Node MCU. When code is dumped into our microcontroller,it sends the required inputs to the respective components through the input pins of Node MCU and the components thus provide us with the required output.

All the code is being dumped into the microcontroller using the Arduino IDE for two microcontrollers separately as we have master slave configuration and components are tested roughly using the Adafruit.IO platform. The cloud server willbe made using HTML (Hypertext Markup Language) and the database which we received from the industry will be managed on the backend of the server using MySQL database management system.

So, our controlling unit Node MCU will ask for the data of sensors to the monitoring unit Node MCU using

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the IP address mentioned in the code. After getting the data it will be displayed on the LCD and after verifying it from our database and displaying on our server too,the same controlling unit Node MCU will send inputs to the relays

connected to it for controlling the AC,gas valve and exhaust fan. We can also handle all these operations by the help of buttons on our server.

III. CONCLUSION

One of the world's most critical issues is food waste. Improper warehouse management is the major source of foodwaste. Yet, with today's technology advancements, this is a resolvable issue to some extent. Based on various studies andsolutions to the current problem, we have come to the conclusion that the IOT sector will provide a very cost-effective solution to the current problem.
Apart from this our main concern behind this project was to make the already existing system which was manual into an automated system i.e previously it needed someone to pay attention towards the system but now our project would help them to reduce their efforts and also any machine handled system does the perfect work than any human thus resulting in exact ripening of banana fruit which was a primary issue inany of the warehouses.

IV. FUTURE SCOPE

i. Can be used for storage in other fruits and vegetables industries.
ii. This project is limited only to banana fruit as we had the data only of banana fruit cold storage systems,but this same system may also be used in storage of various food items such as vegetables,sweets,grains etc in the warehouses.

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